FIG.1

CM   CMTS   CM   CMTS

SEND REQUEST

                                                    CALL SETUP
                                                    CALL ADMITTED
                                                         USG

                                                                    S=1
                                                    VOICE PACKET ACTIVE
                                                         USG

SEND GRANT
                                                                    S=0
                                                    VOICE PACKET, INACTIVE   50

SEND DATA
                                                    REQUEST TO
                                                 ACTIVATE VOICE CALL   52
                                                         USG   54

                                    S=1 S=0   S=1
                                                    VOICE PACKET, ACTIVE
                                                         USG
SEND REQUEST
                                 VOICE PACKET,   S=1
                                    ACTIVE
                                                    DELETE CALL   56
SEND GRANT   CALL DELETED   58
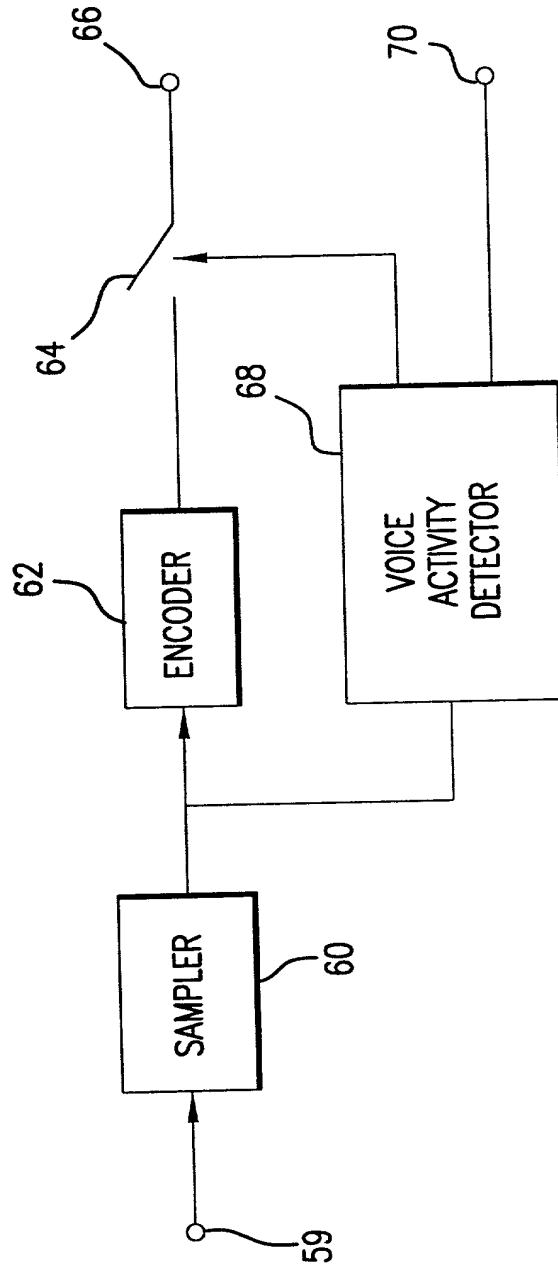
SEND DATA

DATA SERVICE   VOICE SERVICE

FIG.2A   FIG.2B

FIG.3

10 ms = 64 CALLS

FRAME 1 | FRAME 2

FIG.4A

C4

72 — 0   64 CALLS

C1

FIG.4B

2.5 ms

PHASE 1 | PHASE 2 | PHASE 3 | PHASE 4

16 CALLS

16 CALLS   16 CALLS   8 CALLS
(FULL)   (FULL)

FIG.4C

FIG.4D

FRAME SIZE (20 msec)

PHASE 0	PHASE 1	PHASE 2	PHASE 3

VOICE FRAME

5 msec

PHASING

5 msec

FIG.5A

PHASE 0,0	PHASE 0,1	PHASE 1	PHASE 2,0	PHASE 2,1	PHASE 3

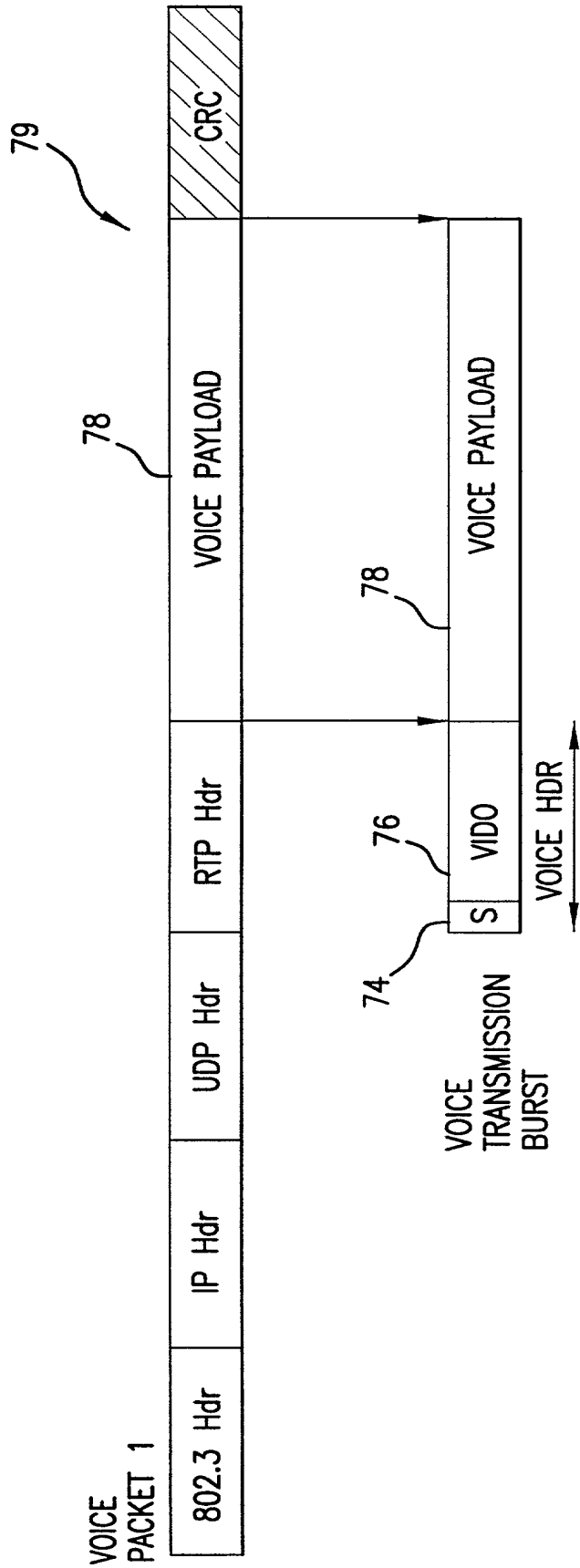VOICE FRAME

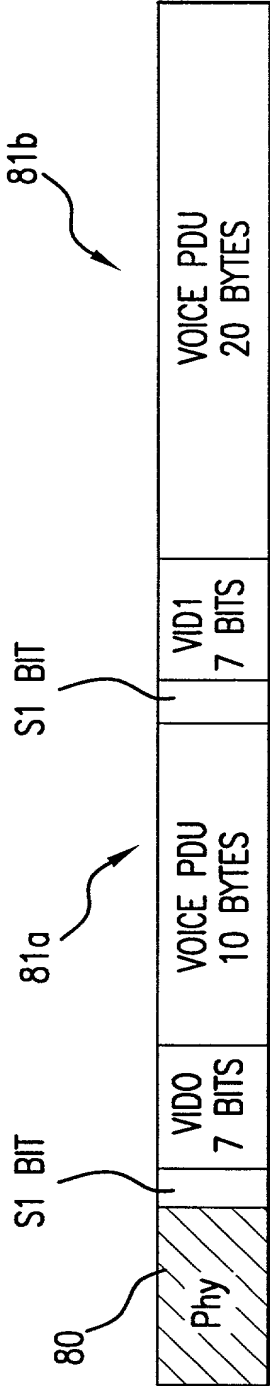2.5 msec

5 msec

SUB PHASING

2.5 msec 5 msec

FIG.5B

CALL 1: CM1, VID0: 5ms, 16 Kbps=2 MS (1:0)
CALL 2: CM2, VID0: 10ms, 32 Kbps=4 MS (2:0)
CALL 3: CM3, VID0: 20ms, 32 Kbps=7 MS (3:0)
CALL 4: CM4, VID0: 20ms, 32 Kbps=7 MS (4:0)
CALL 5: CM1, VID1: 10ms, 16 Kbps=3 MS (1:1)
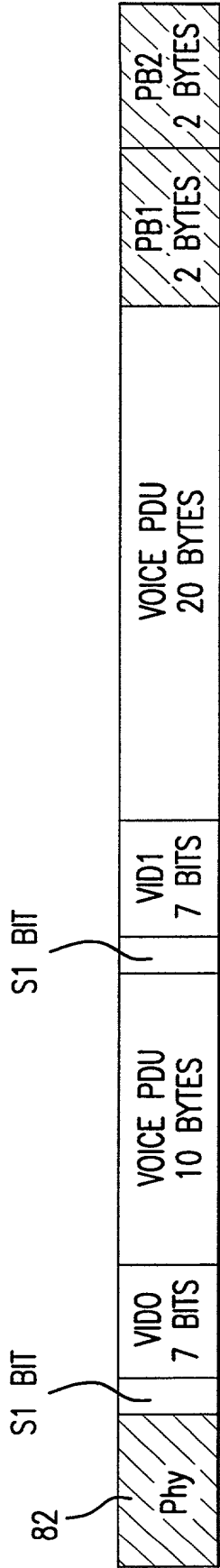CALL 6: CM2, VID1: 10ms, 16 Kbps=3 MS (2:1)

FIG.5C

| 802.3 Hdr | IP Hdr | UDP Hdr | RTP Hdr | VOICE PAYLOAD | CRC |

VOICE PACKET 1

79

78

| S | VIDO | VOICE PAYLOAD |

VOICE TRANSMISSION BURST

74

76

78

VOICE HDR

MAPPING VoIP PACKETS INTO VOICE PDUs

FIG.6A

| Phy | VID0
7 BITS | VOICE PDU
10 BYTES | VID1
7 BITS | VOICE PDU
20 BYTES |

80   S1 BIT   81a   S1 BIT   81b

CONCATENATION OF TWO VOICE CHANNELS OF DIFFERENT RATES

FIG.6B

| Phy | VID0
7 BITS | VOICE PDU
10 BYTES | VID1
7 BITS | VOICE PDU
20 BYTES | PB1
2 BYTES | PB2
2 BYTES |

82   S1 BIT   S1 BIT

CONCATENATION OF VOICE CHANNELS AND PIGGYBACKING REQUESTS

FIG.6C

CALL ADMISSION INITIALIZATION — 84

DETERMINE REPETITION INTERVAL (RI) AS THE LEAST COMMON MULTIPLE OF THE VOICE CODEC PACKETIZATION INTERVALS — 86

CALCULATE
NUMBER OF PHASES (N) = RI/(JITTER BOUND) — 88

CALCULATE
MAX_SLOTS = NUMBER OF MINI-SLOTS IN JITTER BOUND — 90

CREATE N QUEUES AND INITIALIZE THE ARRAY
QueueSize[i] = MAX_SLOTS FOR EVERY i < N — 92

END OF INITIALIZATION — 94

FIG.7

NEW CALL ADDITION

VOICE CALL PARAMETERS: RATE (R), PACKETIZATION INTERVAL (P) AND CABLE MODEM ID.
CALCULATE GRANT SIZE (G) = MS REQUIRED TO TRANSMIT (R*P+VHDR)

OFFSET (O) = P/JB
NUMBER OF QUEUES IN REPETITION INTERVAL (N) = RI/P
i = 0; j = 0

i < 0

N

Y

INCREMENT i

ADMITTED FLAG = TRUE

N

ADMITTED FLAG IS TRUE

N

j < N

Y

ADD THE NEW CALL DECREMENT QueueSize

Y

QueueSize [j*O+i]<G

N

INCREMENT j

CALL IS REJECTED

Y

ADMITTED FLAG = FALSE

END OF CALL ADMISSION

FIG.8

1:1 3 MS	3:0 7 MS	2:0 4 MS	1:0 2 MS

2:1 3 MS	4:0 7 MS	1:0 2 MS

1:1 3 MS	2:0 4 MS	1:0 2 MS

2:1 3 MS	1:0 2 MS

16

CALL ADMISSION: UNBALANCED

FIG.9
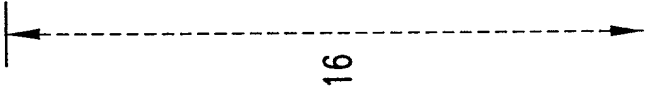
2:1 3 MS	1:1 3 MS	2:0 4 MS	1:0 2 MS

3:0 7 MS	1:0 2 MS

2:1 3 MS	1:1 3 MS	2:0 4 MS	1:0 2 MS

4:0 7 MS	1:0 2 MS

16

CALL ADMISSION: BALANCED

FIG.10

16
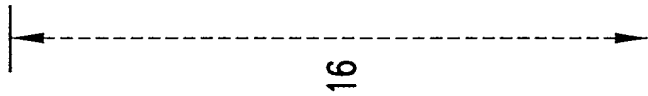
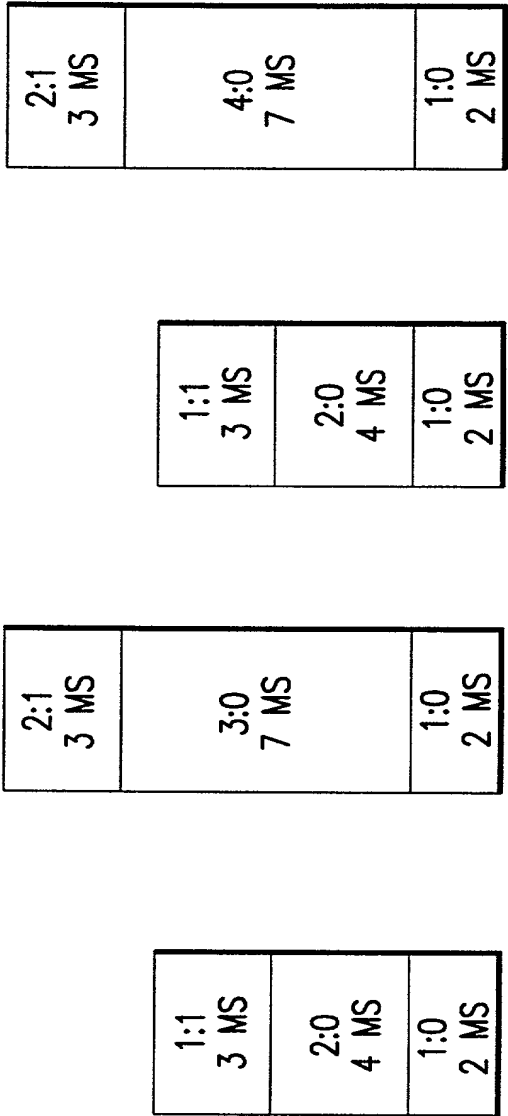| 2:0,1 6 MS | 3:0 7 MS | 2:0,1 6 MS | 4:0 7 MS |
| 1:0,1 4 MS | 1:0 2 MS | 1:0,1 4 MS | 1:0 2 MS |

CALL ADMISSION: BALANCED WITH CONCATENATION

FIG.11

CALL ADMISSION: BALANCED AND DISTRIBUTED CM ALLOCATION
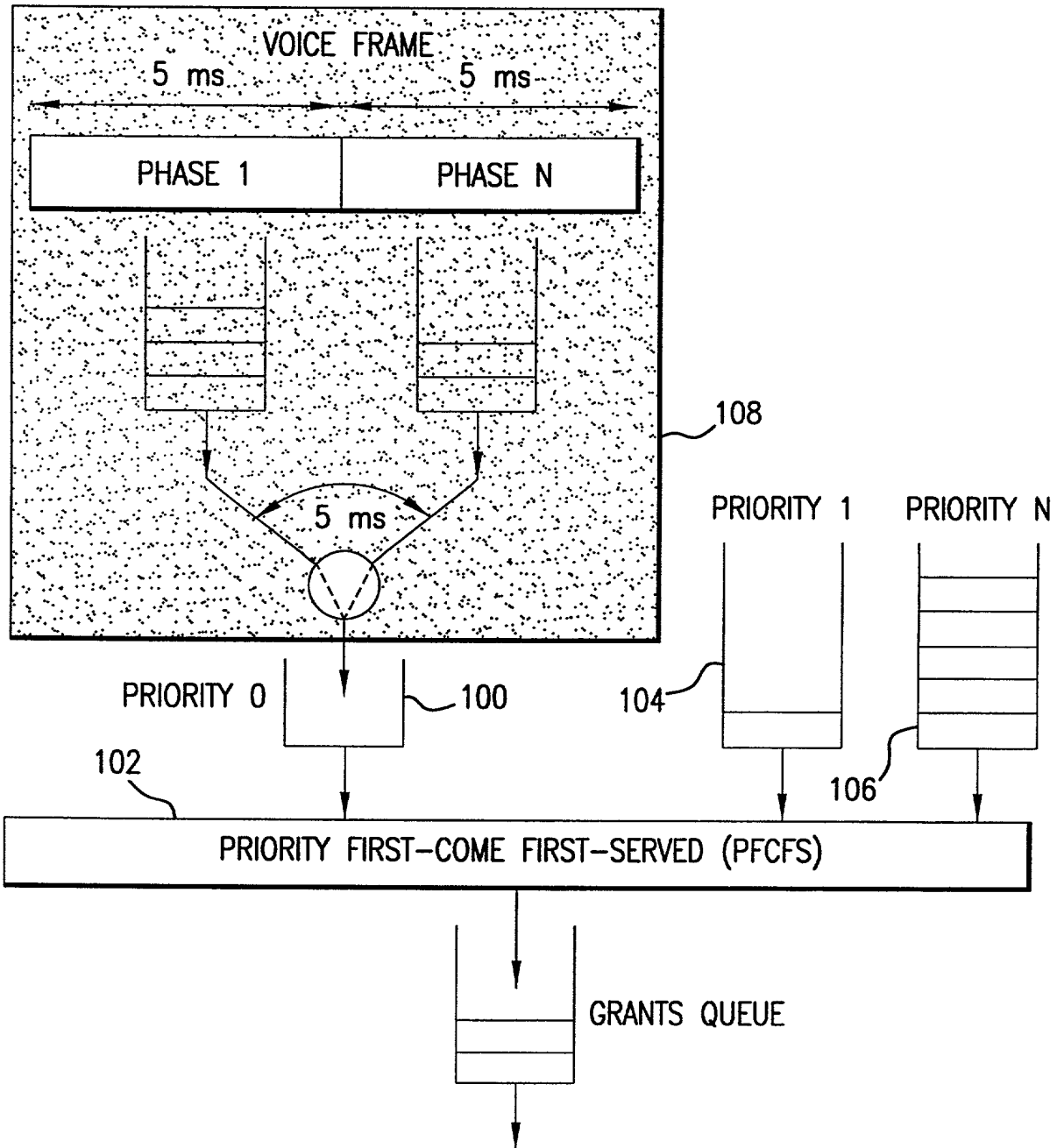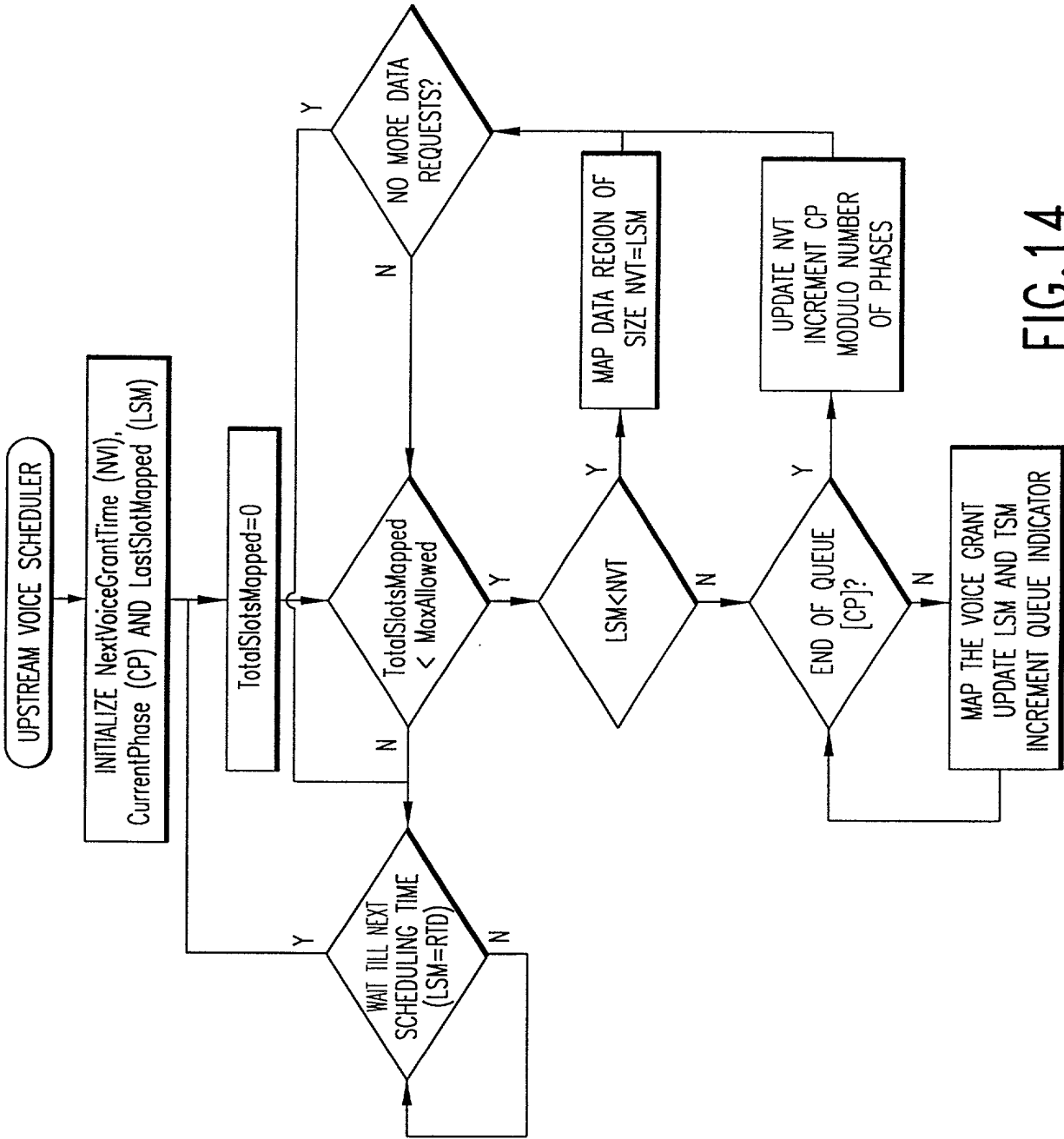
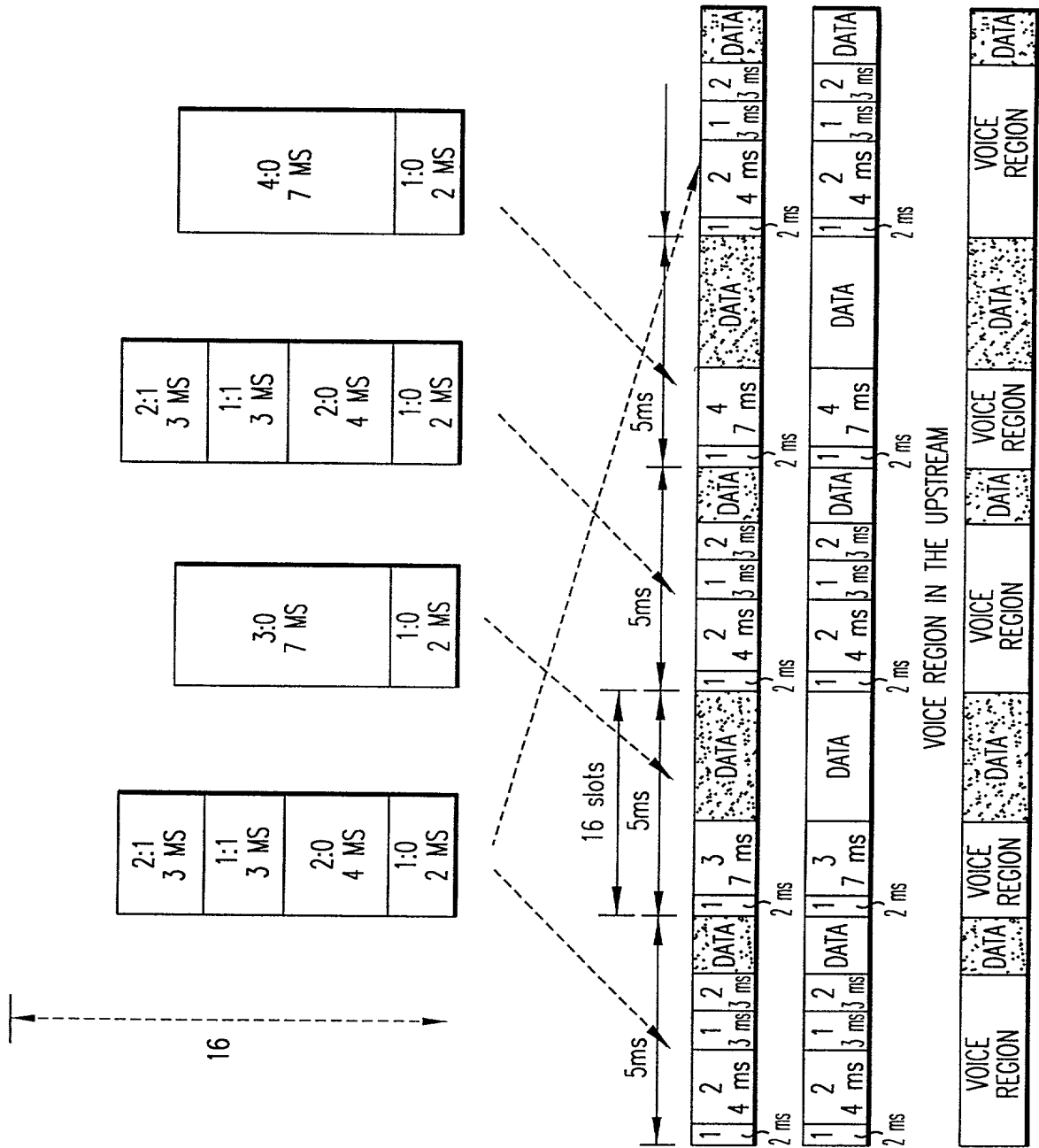FIG.12

(PERIODIC) UNSOLICITED GRANT SERVICE (UGS)

VOICE FRAME

5 ms ↔ 5 ms

| PHASE 1 | PHASE N |

5 ms

108

PRIORITY 1   PRIORITY N

PRIORITY 0   100

104   106

102

PRIORITY FIRST-COME FIRST-SERVED (PFCFS)

GRANTS QUEUE

FIG.13

UPSTREAM VOICE SCHEDULER

INITIALIZE NextVoiceGrantTime (NVI), CurrentPhase (CP) AND LastSlotMapped (LSM)

TotalSlotsMapped=0

NO MORE DATA REQUESTS?

Y

N

TotalSlotsMapped < MaxAllowed

Y

N

MAP DATA REGION OF SIZE NVT=LSM

LSM<NVT

Y

N

UPDATE NVT INCREMENT CP MODULO NUMBER OF PHASES

END OF QUEUE [CP]?

Y

N

MAP THE VOICE GRANT UPDATE LSM AND TSM INCREMENT QUEUE INDICATOR

WAIT TILL NEXT SCHEDULING TIME (LSM=RTD)

Y

N

FIG.14

VOICE REGION IN THE UPSTREAM

DATA REGION IN THE UPSTREAM

VOICE SCHEDULING: MAPPING VOICE STATE INTO UPSTREAM GRANTS

FIG.15

FIG.16

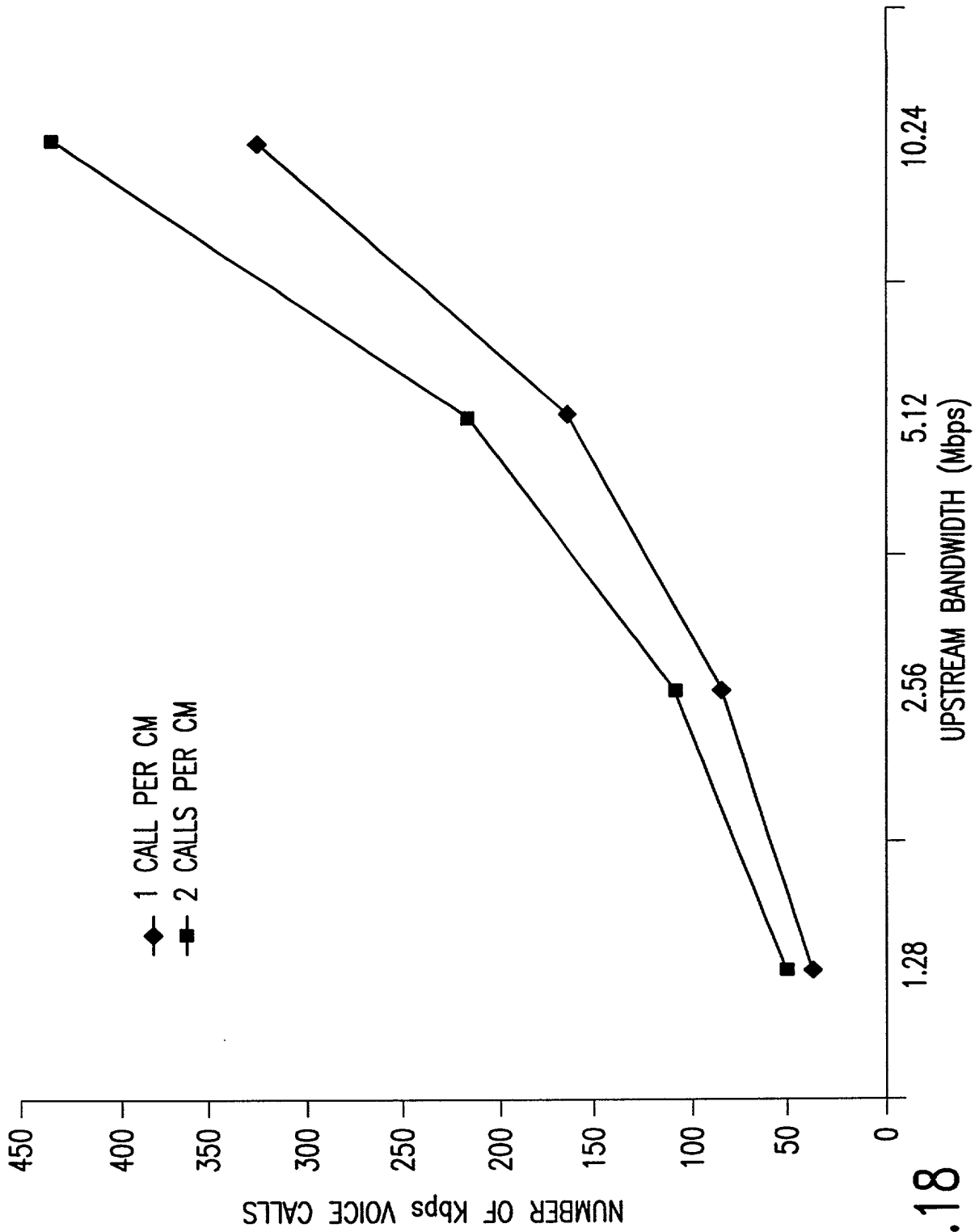DATA PACKETS: PACKET 1 | PACKET 2 | PACKET 3 | Pkt4 |

CONTENTION MINI-SLOT

PHASE A | PHASE B | PHASE A

VOICE FRAME STATE

(a) MAPPING: STRICT FRAGMENTATION

PHASE A

VOICE

VOICE | PACKET 1 | Pck 2, frg 1 | VOICE | P2,f2 | PACKET 3 | P4,f1 | VOICE | P4,f2 |

(b) MAPPING: BACK TO BACK VOICE PHASES

PACKET 1 | Pck 2, frg 1 | VOICE | P2,f2 | PACKET 3 | Pkt4 | VOICE | VOICE |

(c) MAPPING: FLOATING REGION BOUNDARIES

VOICE | PACKET 1 | PACKET 2 | VOICE | PACKET 3 | Pkt4 | VOICE |

(d) MAPPING: FIXED REGION BOUNDARIES: BEST FIT (NO FRAGMENTATION)

VOICE | PACKET 1 | Pkt 4 | VOICE | PACKET 3 | PACKET 2 | VOICE |

FIG.17

FIG.18

INPUT
QUEUES

120n

120c

120b

120a

SWITCH

122

OUTPUT
QUEUES

124n

124c

124b

124a

FIG.19